BEBR

FACULTY WORKING
PAPER NO. 1422

Assessing Benefits of a Network-Based Information System in Distribution Operations

Hirohide Hinomoto

College of Commerce and Business Administration
Bureau of Economic and Business Research
University of Illinois, Urbana-Champaign

BEBR

FACULTY WORKING PAPER NO. 1422

College of Commerce and Business Administration

University of Illinois at Urbana-Champaign

December 1987

Assessing Benefits of a Network-Based Information System in Distribution Operations

Hirohide Hinomoto, Professor
Department of Business Administration

ASSESSING BENEFITS OF A NETWORK-BASED
INFORMATION SYSTEM IN DISTRIBUTION OPERATIONS

ABSTRACT

A producer of consumer chemicals implemented an information system based on a computer network to collect daily-sales information of its distributors and used the information to directly control its own inventory maintained at the distributors' warehouses. This paper presents a post implementation study to assess the impacts of the system on inventory control and the productivity of the business function concerned.

Key Words: Cost/benefit analysis, information system, inventory control.

Acknowledgement: The author acknowledges Kao Corporation's kind arrangements enabling him to interview with its personnel who participated in developing the online system and to visit Kyoto Kao Sales Co., the exclusive distributor discussed in this paper.

ASSESSING BENEFITS OF A NETWORK-BASED
INFORMATION SYSTEM IN DISTRIBUTION OPERATIONS

Introduction

An increasing number of firms have been implementing an online information system based on a computer network to improve order processing and their distribution operations. Typical benefits derived from such systems include a reduction in number of personnel, faster and more accurate order processing, and improved inventory control. This paper is to evaluate the impacts of such a system on office productivity and inventory control at a producer of consumer chemicals.

A number of authors have discussed cost-benefit analysis and other methods of assessing the value of an information system, as is summarized by Hamilton and Chervany [1981a,b]. Earlier, King and Schrems [1978] have interpreted the benefit of a system in two distinguished meanings, efficiency and effectiveness; efficiency is used when benefit can be quantified; otherwise, effectiveness is used. Later, Hamilton and Chervany [1981a] have presented a more elaborate way of evaluating an information system, using two parallel perspectives. One perspective covers the efficiencies of system development, operation, and capacity, whereas the other covers the impacts of the system on the user and other groups in the organization.

Some authors have indicated the merit of applying cost-benefit analysis to an information system in its planning or developing stage [Meals 1977], while others have indicated shortcomings in such applications [Lay 1985]. Lucas [1975] and Carter [1985] have developed models representing benefits of information systems. However, it has

been generally considered difficult to assess the actual benefit of an information system [Dickson and Powers 1973, Keen and Morton 1978, Lientz, et al. 1978, Matlin 1979, Keen 1981; Lay 1985]. Some suggestions have been made to alleviate this difficulty [Cotton 1977, Keim and Janars 1982, Greer and Kropp 1983, Smith 1983]. Apart from these views on cost-benefit analysis, one rarely finds a detailed study determining actual benefits realized by an information system.

The firm, the system, and the situation

The organization discussed here is the consumer product group of Kao Corporation of Japan. As the biggest producer in Japan of laundry products including soap, detergent, and toilet products, the consumer group contributed 84.3% of Kao's gross revenue of $985.9 million in 1981. In the late 1960s, Kao was merely one of the six main producers of detergent in Japan. Then, wholesalers of laundry products were engaged in cutthroat competition without making profit, giving pressure to producers to reduce their margins.

Around that time, the Japanese Government was preparing for liberalization of foreign capital investment, that would allow foreign firms to establish their subsidiaries in Japan. Kao feared that if the liberalization became a law, large foreign producers of laundry products would start marketing their products and quickly capture a major share of the Japanese market. Faced with the looming competition from abroad in addition to the domestic one, Kao considered it urgent to rationalize its operations.

In the mid-1960s, Kao's products were distributed to some 240,000 retailers nationwide through a traditional Japanese distribution system consisting of over 4,000 wholesales forming from two to four hierarchical layers between the producer and the retailer. As an alternative to this cumbersome distribution system, Kao considered a direct distribution system that would bypass wholesalers completely. While this method of distribution might shorten the distance between Kao and the retailer, it possessed strong disadvantages. In view of the traditional Japanese business practice respecting the established buyer-seller relationship, the retailer might not welcome the direct distribution system when it still had to depend on the wholesaler for products from companies other than Kao. Further, Kao thought that the wholesaler would do a better job in selling to the retailer than its own Sales Division, particularly for slow moving items. Kao's final decision was to stick to the traditional distribution system, but it recognized needs for rationalizing the system.

The rationalization was carried out in three stages. The first stage was the reorganization of the system in which some 1,300 wholesalers in large cities representing the major segment of the market were consolidated into 80 exclusive distributors. To achieve this, Kao persuaded on the average a dozen wholesalers in a locality to form a new exclusive distributor, and transfer their business with it to the distributor. It believed that the new distributor could maintain stronger ties with Kao and the retailer because of its greater size, achieve economies of scale in operation, and collect more reliable information on consumer demand than could the individual wholesaler.

The formation of the distributors was carried out during the period of 1966-70.

The second stage of rationalization took place during the period of 1970-74. Its main objective was the incorperation of modern material handling methods in the distribution system. They included the transport of finished products on the same standard pallet throughout the distribution system, covering the factory, the distribution center, and the warehouse of the distributor; the construction in each plant site of an automated warehouse from which products were shipped out under direct control of the host computer at the main office; the construction of a high-rising storage structure with an automatic material handling system at each distribution center; and the development of standard procedures for designing and constructing a warehouse of the distributor. Further, Kao enforced that the distributor placed an order of an item by pallet load, and that ordered items were delivered to the distributor by full truck load.

Until the middle of 1975, Kao used a manual system to process sales orders. In this system, twenty-one clerks received orders from distributors by telephone, transcribed them onto shipping order forms, and sent these forms to the order-entry group. In this group, thirteen keyboard operators keypunched the orders onto a paper tape; and the data in the tape were periodically transmitted by a tape reader to a UNIVAC 1106 in the computer center. Between March 1974 and February

1975, this system handled a total of 153,624 sales orders with 395,136 items received from the distributors.

The establishment of the distributor, however, did not help Kao much in getting reliable information on consumer demand. The distributor determined the order quantity of an item on the basis of its forecast for near-future demand and inventory on hand. Having no knowledge of the distributor's inventory, it could not estimate the current consumer demand on the basis of the order received from the distributor. Although it subscribed the Nielsen market survey on demands for its products, it had to wait two months before getting the sufvey's result. It needed better market information to improve its inventory management and production planning.

The third stage of rationalization was the implementation of information systems to support the reorganized distribution system in the areas of market analysis and planning, shipping order processing, and production control. The main thrust of this stage was, however, the development of an online information system, called the "online supply" (OS) system, to control inventory at the distributor's warehouse by establishing a direct linkage between Kao's main-frame computer and the minicomputers of distributors. The development of the online system started in 1972 and completed in 1974.

With the emergence of minicomputers in the early 70s, for the first time smaller firms like Kao's distributors could possess their own computers. Seizing this opportunity, Kao advised the distributors to acquire a minicomputer of specific model and offered them any technical support they might need. Their acquisition of mini-computers

was closely coordinated with the inclusion of the mini-computers into the OS system. In 1975, as the first step in implementing the OS system, the host computer at Kao's central office was connected with minicomputers at four distributors. The conversion for the remaining distributors was carried out over the period of 1976-78 in four stages in each of which a new group of distributors was integrated into the OS system.

Prior to the integration of a distributor, in a radical departure from the traditional business practice, Kao bought back inventory in the distributor's warehouse and leased the warehouse to maintain its own inventory. In the new arrangement, the distributor's order pickers picked and shipped out products as before, and entered order details into the minicomputer system from an online terminal in the warehouse. At the end of business, the minicomputer summed up quantities shipped by product and by type of retailer, and printed out these sums and their total charge as a daily sales report. The summary data were transmitted through the telephone line from the minicomputer to the host computer and then used to update the distributor's inventory record in the online inventory file of the host computer. When the on-hand quantity of a product in the record dropped below an acceptable level, the host computer directed an online printer at an appropriate factory or distribution center to print out a shipping order to deliver a prescribed volume of the product to the distributor the following day.

The conversion to the OS system eliminated all manual tasks needed for order processing and distribution in the previous system, including customer order receiving, keypunching order data onto a tape, transmitting these data through a tape reader to the computer system, teletyping shipping orders to distribution centers or manufacturing plants, and sending bills to distributors. This resulted in a reduction in size of clerical employees in the order receiving group from 51 to 34, and the transfer of 13 keypunchers in the order entry group to other jobs.

Insert Figure 1 about here

A schematic representation of the OS system is shown in Figure 1. The system consisted of a UNIVAC 1100/81 as its host computer installed at the central computer center, two PDP 11/34 as front-end processors, 100 Melcom 80/38 minicomputers installed at 20 distribution centers and 80 distributors, and a UNIVAC 1100/21 installed at each of the six plants.

Evaluation of System Efficiency

In the initial proposal, the OS system was expected to reduce the operating cost of the business function concerned because of the reduction in workforce and bring about some indeterminate benefits, such as more efficient and accurate order processing because of the elimination of manual tasks. Further, the ability of the system to collect information on customer demand closer to the market than before might improve inventory control and production planning.

Two of the most significant improvements actually realized were those in inventory control and system efficiency--the efficiency of the office unit performing an assigned business function or functions with the support of the information system concerned. It is infeasible, however, to compare the efficiencies of the old and new systems in any direct manner because of fundamental differences in their input and output formats. To resolve this difficulty, their efficiencies will be compared through an indirect means using the economic concept of productivity.

Economists have been measuring the productivity of a firm. The most important productivity measure is the total factor productivity ratio representing output per unit of all inputs. Normally, revenue represents output, while inputs include materials, labor, and capital. Some economists prefer to use value-added revenue--gross revenue minus costs of materials and services acquired from outside--as output, since it gives a better measure of the firm's real production (Dickson and Powers, 1973). Thus, the following formula represents the (total factor) productivity measure:

$$\text{Productivity} = \frac{\text{Gross or valued-added revenue in dollars}}{\text{Cost of labor, material and capital in dollars}}$$

The above productivity concept is used to measure economic impacts of the new system with two sets of data: one is data in 1975, just before the start of the system conversion, with dollar values adjusted to those in 1981; and the other is data in 1981, a few years after the conversion.

The Order Processing/Distribution Function

The value-added revenues of the consumer product group in 1975 and 1981 were $162.4 million and $219.7 million, respectively (see Table 1). Table 3 lists various inputs to the office function concerned. The total input to the order processing/distribution function in 1975 was $1.454 million, including personnel, computer-center resources allocated to the information system based on its CPU time, and program maintenance. The order processing application software was developed by the computer vendor and its cost was included in the hardware lease cost. The total input in 1981 was $1.291 million, including the above items, data transmission as the only major operational item for connecting the minicomputer with the host, and system-development cost being amortized over six years. The productivity measures of the business function in the two years are

$$\text{Productivity in 1975} = \frac{162.4}{1.454} = 112$$

$$\text{Productivity in 1981} = \frac{219.7}{1.291} = 170$$

The above results indicate that the productivity of the user unit performing the order procesing distribution function has increased as much as 52% after the system conversion.

Inventory Control

The availability of daily sales information at the distributor level significantly improved Kao's ability to control its inventory. This improvement is determined by examining the total inventory of the distribution system consisting of plants, distribution centers and

distributors. While the annual revenue of the consumer product group increased from \$615 million to \$831 million between 1975 and 1981, the average monthly inventory at cost of the distribution system decreased from \$77.3 millions to \$55.2 million. The reduction in average monthly inventory was attributable to (1) a decrease in buffer inventory kept at the plants and distribution centers from \$35.1 million to \$17.1 million, and (2) a decrease inventory maintained at the distributors' warehouses from \$42.2 million to \$38.1 million, or from 1.4 to .9 as a factor of average monthly requirement, as is shown in Table 1.

The estimation of savings in inventory carrying cost realized by the system conversion is complicated by the fact that the distributor carried own inventory in 1975 but not in 1981. Consequently, the following two extreme cases are evaluated: (Case a) Kao maintained inventory at the entire distribution system, and (Case b) Kao carried inventory at its warehouses and distribution centers only. Had the old system been still in use, Kao would have needed the following inventory in 1981:

Case a. $$(77.3 \times \frac{831.1}{615.0}) = \$104.5 \text{ million/month}$$

Case b. $$(35.1 \times \frac{831.1}{615.0}) = \$47.4 \text{ million/month}$$

With a discount rate of 19.3 percent, Kao's average rate of return on equity during the period of 1975-81, the saving in inventory carrying cost for Kao in each case was as follows:

Case a. $(104.5-55.2) \times .193 = \$9.51$ million/year

Case b. $(47.4-17.1) \times .193 = \$5.85$ million/year

Since the above values represent the possible maximum and minimum estimates for annual inventory carrying cost, the actual saving may have been somewhere between $9.51 million and $5.85 million. Even the lower estimate of $5.85 million is more than ten times the labor cost saving realized by the reduction of 30 office personnel. It is interesting to note that the economic feasibility of the new system in the original proposal was based solely on the expected saving in labor cost alone while the benefit derived from improved inventory control was treated as an intangible.

Conclusion

This paper has examined main economic impacts of an online information system based on a computer network implemented by a producer of consumer chemicals as the last phase of a strategic plan for improving its distribution operation.

The new information system succeeded in radically reducing inventory in the entire distribution system because of its abilities to collect formerly unavailable, daily sales information at the distributor level and to directly control inventory at the distributor's warehouse. The average inventory was decreased from 12.6% of the gross revenue to 6.6% between 1975 and 1981, which amounted to an estimated saving of at least $5.85 million in inventory carrying cost in 1981.

REFERENCES

Carter, M. P., 1985, "The Valuing of Management Information Part I: The Bayseian Approach," Journal of Information Science, Vol. 10, No. 3, pp. 1-9.

Cotton, I. W., 1977, "Cost-Benefit Analysis of Interactive Systems," Computer Networks, Vol. 1, No. 6, pp. 311-324.

Dickson, G. W., and Powers, R. F., 1973, "MIS Project Management: Myths, Opinions, and Reality," California Management Review, Vol. 15, No. 1, pp. 147-156.

Greer, W. R., Jr. and Kropp, D. H., 1983, "The Incremental Benefits of Changes in the Timeliness of Information," Information and Management, Vol. 6, pp. 329-336.

Hamilton, S., and Chervany, N. L., 1981a, "Evaluating Information Systems effectiveness--Part I: Comparing Evaluation Approaches," MIS Quarterly, Vol. 5, No. 3, pp. 55-69.

______________, 1981b, "Evaluating Information Systems Effectiveness--Part II: Comparing Evaluator Viewpoints," MIS Quarterly, Vol. 5, No. 4, pp. 79-86.

Keen, P. G. W., 1981, "Value Analysis: Justifying Decision Support Systems," MIS Quarterly, Vol. 5, No. 1, pp. 1-15.

______________, and Morton, M. S., 1978, Decision Support Systems: An Organizational Perspective, Addison Wesley, Reading, Massachusetts.

Keim, R. T., and Janars, R., 1982, "Cost/Benefit Analysis of MIS," Journal of Systems Management, Vol. 33, No. 9, pp. 20-25.

King, J. L. and Schrems, E. L., 1978, "Cost-Benefit Analysis in Information Systems Development and Operations," Computing Survey, Vol. 10, No. 1, pp. 19-34.

Lay, P. M. W., 1985, "Beware of the Cost/Benefit Model for IS Project Evaluation," Journal of Systems Management, Vol. 36, No. 6, pp. 30-35.

Lientz, B. P., Swanson, E. B., and Tompkins, G. E., 1978, "Characteristics of Application Software Maintenance," Communications of the ACM, Vol. 21, No. 6, pp. 466-471.

Lucas, H. C., Jr., 1975, "Performance and Use of an Information System," Management Science, Vol. 21, No. 4, pp. 908-919.

Matlin, G., 1979, "What is the Value of Investment in Information Systems?" MIS Quarterly, Vol. 3, No. 3, pp. 5-34.

Meals, D. W., 1977, "System Evaluation," Journal of Systems Management, Vol. 16, No. 7, pp. 6-9.

Norton, D. P., and Rau, K. G., 1978, A Guide to EDP Performance Management, QED Information Sciences, Wesley, Massachusetts.

Smith, R., 1983, "Measuring the Intangible Benefits of Computer-Based Information Systems," Journal of Systems Management, Vol. 34, pp. 22-27.

Figure 1

Online Supply System